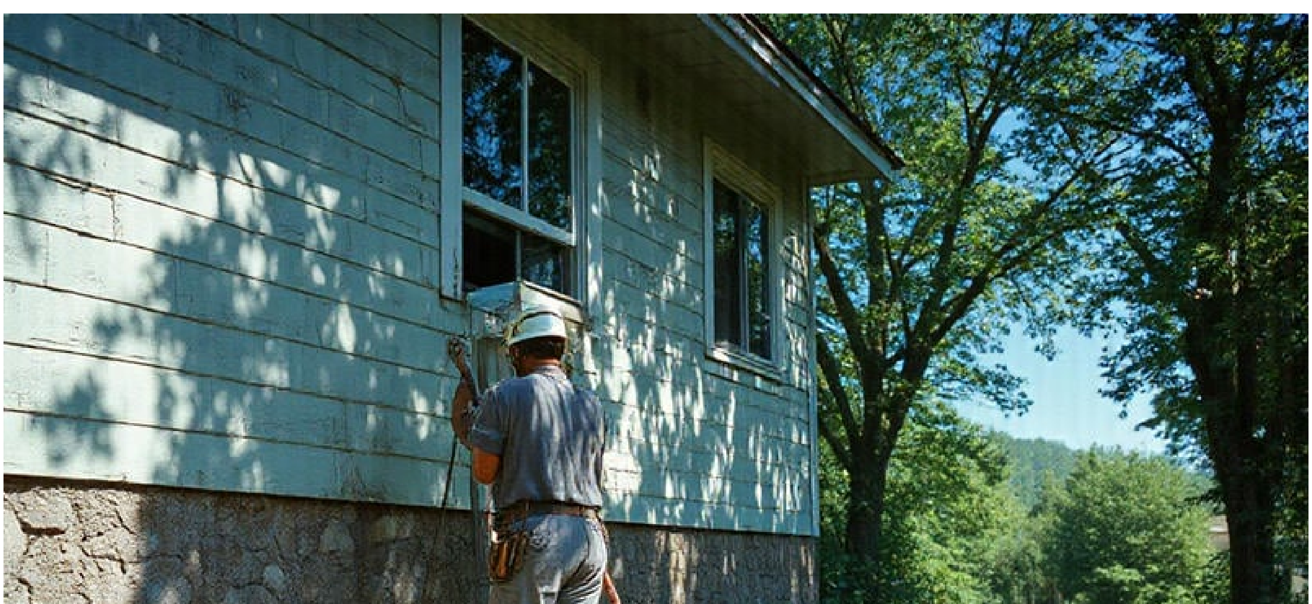
Foundation Safety

- **Project Logistics Permitting and QA QC**
  Project Logistics Permitting and QA QC Steps to Secure a Municipal Foundation Repair Permit Coordinating Utility Markouts Before Pier Drilling Developing a Work Sequence to Minimize Downtime Creating a Safety Plan That Meets OSHA Guidelines Scheduling Third Party Inspections for Key Milestones Preparing As Built Elevation Logs for Engineer Review Managing Material Deliveries on Confined Job Sites Using Checklists to Track QA QC Tasks in Real Time Budget Control Methods for Foundation Projects Communication Strategies With Homeowners During Repairs Document Storage Solutions for Project Records Closing Out a Permit After Final Inspection Approval
- **Cost Financing and Warranty Structures**
  Cost Financing and Warranty Structures Factors That Influence Foundation Repair Pricing Understanding Pier Installation Quotes Line by Line Comparing Financing Options for Structural Repairs How Transferable Warranties Protect Future Owners Common Exclusions Found in Foundation Repair Contracts Calculating Return on Investment for Underpinning Services Payment Schedule Ideas to Align With Work Progress Evaluating Insurance Coverage for Structural Damage Estimating Long Term Savings From Preventive Upgrades Negotiating Warranty Terms With Contractors Impact of Material Choice on Overall Project Cost Tracking Repair Expenses for Tax Documentation
- **About Us**



Damage

Project Scope Definition and Permitting Requirements for Foundation Repair

Understanding foundation damage is crucial when evaluating insurance coverage for structural damage, as it directly impacts the integrity and safety of a building. Foundations serve as the critical support for any structure, distributing loads evenly to prevent collapse or deformation. When this base is compromised, the consequences can be severe, ranging from minor cracks in walls to catastrophic failure of the entire building.

Common causes of foundation damage include soil movement, which can occur due to several factors. Expansive soils that swell when wet and shrink when dry are notorious for causing upheaval or settling of foundations. This type of soil movement is often seen in areas with significant seasonal moisture changes. Another frequent culprit is poor drainage around a property, where water accumulation near the foundation leads to soil erosion or saturation, weakening the support beneath the structure.

Foundation issues have this infuriating way of starting small and then blooming into financial nightmares like some sort of monetary horror film **concrete foundation stabilization Palatine** technology.

Additionally, construction defects play a significant role. If a foundation was not designed or built correctly for the specific soil conditions or load requirements of the building, it might fail prematurely. This could involve inadequate reinforcement, improper curing of concrete, or incorrect depth placement relative to frost lines in colder climates.

When homeowners face foundation issues, they turn to their insurance policies hoping for coverage. However, standard homeowners insurance typically does not cover damages from earth movement like settling or shifting unless its due to a sudden event like an earthquake (which would require additional earthquake insurance). Policies might exclude gradual damage from natural wear and tear or neglect in maintenance like poor drainage management.

Therefore, understanding these common causes and how they relate to your policys exclusions and inclusions is vital. Homeowners should review their insurance contracts carefully, looking for terms related to "earth movement," "settling," "foundation," and similar phrases. Sometimes, specific endorsements or riders can be added to extend coverage for certain types of foundational damage if they are not included in the basic policy.

In conclusion, while foundation damage can stem from various sources often linked with natural geological processes or human error in construction, securing adequate insurance coverage requires a deep dive into policy specifics. Homeowners must be proactive in understanding both their homes vulnerabilities and their insurance policys scope to ensure they are protected against potential costly repairs resulting from foundation failures.

When evaluating insurance coverage for structural damage, its essential to understand the various types of insurance policies and what they cover in terms of structural issues. Structural damage can arise from numerous causes such as natural disasters, accidents, or wear and tear over time, each requiring a nuanced approach to insurance.

Homeowners insurance is the most common policy that offers a baseline of protection against structural damage. Typically, this policy covers damages caused by events like fire, windstorms, hail, and sometimes even lightning. However, its crucial to note that standard homeowners policies often exclude certain natural disasters such as floods and earthquakes unless specific additional endorsements or separate policies are purchased. For instance, flood insurance, which is not part of standard homeowners coverage, must be obtained separately through programs like the National Flood Insurance Program (NFIP) in the U.S.

For those living in seismically active areas, earthquake insurance becomes particularly relevant. This type of policy specifically addresses damages caused by seismic activity but comes with its own set of exclusions and deductibles which can be quite high compared to other insurance types.

Another aspect to consider is coverage for gradual damage or deterioration. Standard policies might not cover structural issues arising from neglect or aging unless theres an accidental event involved. Heres where home warranty plans might complement traditional insurance by offering repair or replacement services for systems breaking down due to age or normal wear.

Additionally, for business owners or those with commercial properties, commercial property insurance plays a similar role to homeowners insurance but tailored for business-related risks. This includes not only physical damage but also business interruption coverage if the structure becomes uninhabitable due to a covered peril.

When reviewing these policies for structural damage coverage, one should pay attention to the policy limits, which dictate the maximum amount an insurer will pay out; deductibles, which are out-of-pocket expenses before insurance kicks in; and exclusions, which detail what isnt covered. Its also wise to look into whether your policy provides replacement cost value (RCV) or actual cash value (ACV). RCV will pay for rebuilding at current prices without depreciation, whereas ACV considers depreciation before payout.

In conclusion, securing adequate coverage for structural issues involves understanding the specifics of each policy type relevant to your situation-be it residential or commercial-and ensuring you have additional protections where necessary against specific risks like floods or earthquakes. Consulting with an insurance agent can provide personalized insights into crafting a comprehensive plan that safeguards your property against potential structural damages while fitting within your financial framework.

Material Procurement and Quality Control Procedures

When evaluating insurance coverage for structural damage, understanding the decoding policy language becomes crucial. This process involves dissecting the often complex and nuanced terms found within insurance policies that relate to foundations and other structural components of buildings. Key terms in this context include foundation, which refers to the base on which a structure is built, encompassing elements like footings, slabs, and basement walls. Another important term is structural damage, which typically means any physical harm that affects the integrity or load-bearing capacity of these foundational elements.

One must pay close attention to exclusions within the policy. Common exclusions might involve earth movement, covering events like earthquakes, landslides, or sinkholes, which are not covered under standard policies unless specifically added through endorsements. Similarly, wear and tear or gradual deterioration are often excluded because they represent damage over time rather than sudden events. Policies might also exclude damage due to settling, where the foundation shifts or sinks gradually post-construction.

Understanding these exclusions is vital as they define what isnt covered, potentially leaving policyholders vulnerable if not properly addressed with additional coverage. For instance, if a foundation cracks due to soil expansion from moisture changes-a common issue in many regions-this might fall under an exclusion like soil conditions unless explicitly included in the policy.

To navigate these complexities effectively, homeowners should work closely with their insurance agents. Agents can help clarify whether specific scenarios like subsidence or frost heave are covered or if additional riders need to be purchased for comprehensive protection. Its also beneficial to review past claims data or local geological reports which might influence what kind of coverage is necessary.

In summary, decoding the language of insurance policies concerning foundations requires a keen eye for detail regarding both inclusions and exclusions. This ensures homeowners are adequately protected against potential structural damages while avoiding surprises when filing claims. By thoroughly understanding these terms and working with knowledgeable professionals, one can secure peace of mind regarding ones most significant investment-their homes foundation.

Inspection and Testing Protocols During Foundation Repair

Okay, so youve noticed somethings up with your foundation. Cracks, sinking, bowing walls – not good. And youre hoping your insurance might help. Smart move to check. But before you get too far ahead of yourself, lets talk about documenting and reporting that foundation damage to your insurer. Think of it as building a strong case, brick by brick.

First, documentation is your friend. Start taking pictures, lots of them. Get close-ups of the damage – the size and shape of cracks, any water stains, anything that looks off. Then, take wider shots to show the damage in context. How does it relate to the rest of the house? Is it near a downspout? Is the ground sloping towards your foundation in that area? Dates and times are crucial too, so make sure your pictures are timestamped or keep a detailed log.

Next, gather any historical information you have about your house. Did you have a home inspection when you bought it? Any previous repairs done to the foundation? All of this can help establish whether the damage is new or pre-existing. A pre-existing condition may not be covered, but its still important to be upfront about it.

Now, about reporting it to your insurer. Dont delay. Most policies have time limits for reporting claims. Call them as soon as you reasonably can. Be clear and concise when describing the damage. Stick to the facts; dont speculate about the cause just yet. Remember, youre reporting the *damage* at this stage, not assigning blame.

During that initial call, ask about your policys coverage for foundation damage. What are the specific exclusions? What documentation will they require? Get the claim number and the name of the adjuster assigned to your case. Keep a record of every conversation you have with the insurance company – date, time, who you spoke with, and what was discussed.

After youve reported the damage, your insurer will likely want to send out an adjuster to inspect the property. Be prepared to walk them through the damage and provide them with all the documentation youve gathered. Dont be afraid to ask questions and take notes during the inspection.

Finally, understand that dealing with insurance can be a process. It might take time for them to investigate and make a decision. Stay organized, keep communicating with your adjuster, and dont hesitate to seek professional advice from a structural engineer or public adjuster if you feel like youre not being treated fairly. Documenting and reporting thoroughly from the outset will give you the best chance of a positive outcome. Good luck!

Documentation and Reporting for Permitting Compliance and QA/QC

The process of handling an insurance claim for structural damage can be intricate, involving several key stages: inspection, assessment, and negotiation. When structural damage occurs, whether from natural disasters, accidents, or wear and tear, the first step in evaluating insurance coverage is typically an inspection. This involves a professional assessor visiting the site to physically examine the extent of the damage. They look for visible signs like cracks in walls, sagging roofs, or compromised foundations, but also consider less obvious issues that might affect the buildings integrity over time.

Following the inspection comes the assessment phase. Here, the assessor compiles their findings into a detailed report which quantifies the damage in terms of repair costs and necessary actions. This report is crucial as it forms the basis for what will be covered under the policyholders insurance. Its not just about listing damages; it involves understanding policy limits, exclusions, and whether certain aspects of damage are covered under specific clauses like acts of God or standard wear and tear exclusions.

The final stage is negotiation. Often, theres a gap between what the insurance company initially offers based on their assessment and what the policyholder believes they should receive. This stage requires clear communication and sometimes mediation by professionals like public adjusters or lawyers who specialize in insurance claims. Negotiation isnt just about getting more money; its about ensuring that all aspects of repair are adequately funded to restore the property to its pre-damage condition or better. Here, understanding ones policy details becomes paramount as it can influence how much leverage one has during negotiations.

Navigating through these stages effectively requires patience, documentation, and often a bit of advocacy. Each step builds upon the last, with inspection setting the scene for assessment which then leads into negotiation. Understanding this process helps policyholders manage expectations and actively participate in ensuring their coverage works as intended when structural damage strikes.

Risk Management and Mitigation Strategies in Project

Logistics

So, you filed a claim for structural damage, maybe after a storm or some other disaster, and…denied. It's a punch to the gut, right? You pay your premiums, you expect the insurance company to be there when things go sideways, and then you get a letter saying “nope.” Don't despair. It's not necessarily the end of the road.

The first thing to do is understand why your claim was denied. The denial letter should explain the reason, and it's crucial to read it closely. Was it something about the cause of the damage being excluded in your policy? Did they dispute the extent of the damage? Understanding the reason is the key to figuring out your next move.

Once you know why they denied the claim, you have options, and the first, and often most effective, is to appeal. Insurance companies are businesses, and sometimes mistakes happen. A well-documented appeal, where you clearly and logically address the reasons for the denial, can be successful. Gather evidence to support your claim. This could include independent inspections, expert opinions, detailed repair estimates, or even photos and videos documenting the damage. The stronger your evidence, the better your chances.

Your insurance policy outlines the specific appeal process. Follow it meticulously. Missed deadlines or incomplete paperwork can derail your appeal before it even gets a fair hearing. Be persistent and patient. Appeals can take time.

If the appeal doesnt work, or if you believe the insurance company is acting in bad faith, it might be time to consider seeking legal counsel. Insurance policies are complex legal documents, and insurance companies have teams of lawyers on their side. A lawyer specializing in insurance claims can review your policy, assess the situation, and advise you on your legal options. They can negotiate with the insurance company on your behalf or, if necessary, file a lawsuit.

Hiring a lawyer is a big decision, and it's important to find someone you trust and who has experience with similar cases. Legal representation can be expensive, so discuss the costs and potential benefits upfront.

Ultimately, dealing with a denied insurance claim can be frustrating and overwhelming. But knowing your options – appealing the decision yourself or seeking legal counsel – can empower you to fight for the coverage you deserve and get your home back on track.

Post-Repair Verification and Long-Term Monitoring for QA/QC

When evaluating insurance coverage for structural damage, its crucial to consider the role of preventative measures and maintaining your foundation. These practices not only minimize the risk of damage but can also influence your insurance premiums and claims processes.

Preventative measures start with regular inspections of your property. This includes checking for signs of wear or damage that could compromise the structure, such as cracks in walls or floors, which might indicate foundation issues. By addressing these early signs, you prevent minor problems from escalating into major, costly repairs. For instance, ensuring proper drainage around your home can prevent water from seeping into the foundation, which is a common cause of structural damage.

Maintaining your foundation involves more than just reactive repairs; its about proactive care. This might include reinforcing older foundations or using sealants to protect against moisture. In areas prone to specific risks like earthquakes or heavy snowfall, additional measures like installing seismic retrofits or snow guards can be invaluable. These steps not only safeguard your home but also demonstrate to insurers that you are taking responsibility for reducing potential risks.

From an insurance perspective, a well-maintained property with implemented preventative measures often translates into lower premiums because it represents a lower risk to the insurer. Moreover, should you need to file a claim due to unforeseen circumstances, having documentation of your maintenance efforts can streamline the process. Insurers appreciate homeowners who take steps to mitigate risks as it reduces their exposure to large payouts.

In conclusion, when looking at insurance coverage for structural damage, integrating preventative measures and maintaining your foundation is not just about protecting your home; its about making a wise financial decision. It enhances the resilience of your property against various threats while potentially lowering insurance costs and simplifying claim procedures. This proactive approach ensures that both you and your insurer are on the same page when it comes to safeguarding one of your most significant investments-your home.

About Piling

For other uses, see Piling (disambiguation).

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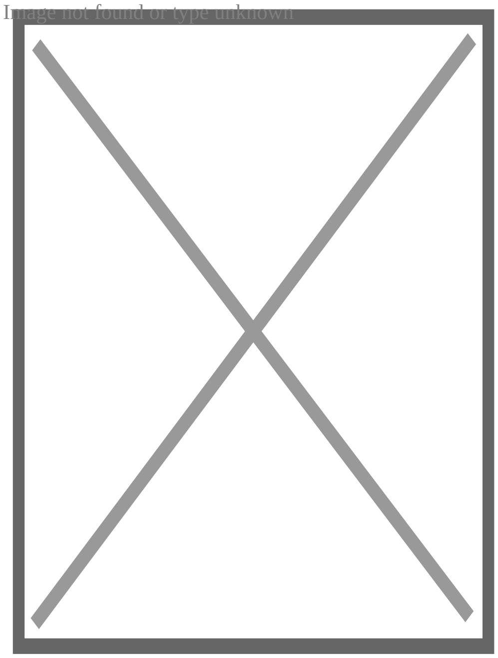
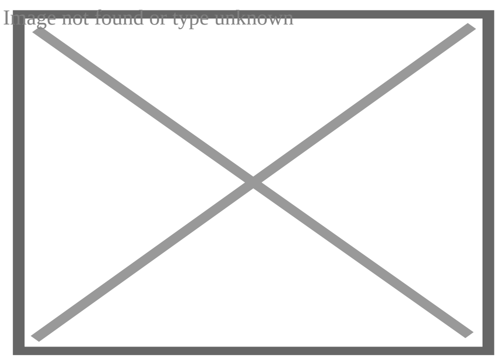
Drilling of deep piles of diameter 150 cm in bridge 423 near Ness Ziona, Israel

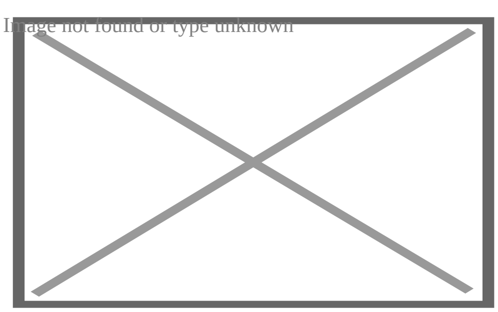


A deep foundation installation for a bridge in Napa, California, United States.



Pile driving operations in the Port of Tampa, Florida.

A **pile** or **piling** is a vertical structural element of a deep foundation, driven or drilled deep into the ground at the building site. A deep foundation is a type of foundation that transfers building loads to the earth farther down from the surface than a shallow foundation does to a subsurface layer or a range of depths.



Deep foundations of The Marina Torch, a skyscraper in Dubai

There are many reasons that a geotechnical engineer would recommend a deep foundation over a shallow foundation, such as for a skyscraper. Some of the common reasons are very large design loads, a poor soil at shallow depth, or site constraints like property lines. There are different terms used to describe different types of deep foundations including the pile (which is analogous to a pole), the pier (which is analogous to a column), drilled shafts, and caissons. Piles are generally driven into the ground *in situ*; other deep foundations are typically put in place using excavation and drilling. The naming conventions may vary between engineering disciplines and firms. Deep foundations can be made out of timber, steel, reinforced concrete or prestressed concrete.

Driven foundations

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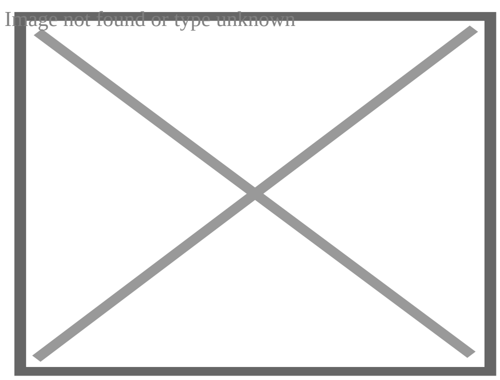

Pipe piles being driven into the ground

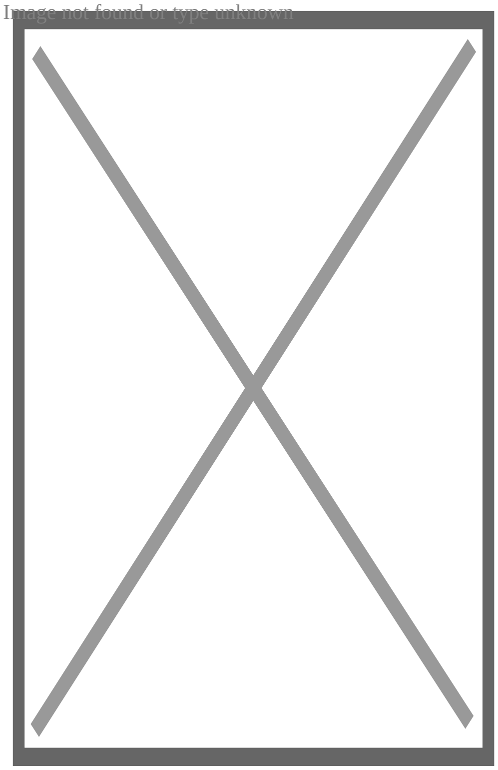

Illustration of a hand-operated pile driver in Germany after 1480

Prefabricated piles are driven into the ground using a pile driver. Driven piles are constructed of wood, reinforced concrete, or steel. Wooden piles are made from the trunks of tall trees. Concrete piles are available in square, octagonal, and round cross-sections (like Franki piles). They are reinforced with rebar and are often prestressed. Steel piles are either pipe piles or some sort of beam section (like an H-pile). Historically, wood piles used splices to join multiple segments end-to-end when the driven depth required was too long for a single pile; today, splicing is common with steel piles, though concrete piles can be spliced with mechanical and other means. Driving piles, as opposed to drilling shafts, is advantageous because the soil displaced by driving the piles compresses the surrounding soil, causing greater friction against the sides of the piles, thus increasing their load-bearing capacity. Driven piles are also considered to be "tested" for weight-bearing ability because of their method of installation.[*citation needed*]

Pile foundation systems

[edit]

Foundations relying on driven piles often have groups of piles connected by a pile cap (a large concrete block into which the heads of the piles are embedded) to distribute loads that are greater than one pile can bear. Pile caps and isolated piles are typically connected with grade beams to tie the foundation elements together; lighter structural elements bear on the grade beams, while heavier elements bear directly on the pile cap.[*citation needed*]

Monopile foundation

[edit]

A **monopile foundation** utilizes a single, generally large-diameter, foundation structural element to support all the loads (weight, wind, etc.) of a large above-surface structure.

A large number of monopile foundations[1] have been utilized in recent years for economically constructing fixed-bottom offshore wind farms in shallow-water subsea locations.[2] For example, the Horns Rev wind farm in the North Sea west of Denmark utilizes 80 large monopiles of 4 metres diameter sunk 25 meters deep into the seabed,[3] while the Lynn and Inner Dowsing Wind Farm off the coast of England went online in 2008 with over 100 turbines, each mounted on a 4.7-metre-diameter monopile foundation in ocean depths up to 18 metres.[4]

The typical construction process for a wind turbine subsea monopile foundation in sand includes driving a large hollow steel pile, of some 4 m in diameter with approximately 50mm thick walls, some 25 m deep into the seabed, through a 0.5 m layer of larger stone and gravel to minimize erosion around the pile. A transition piece (complete with pre-installed features such as boat-landing arrangement, cathodic protection, cable ducts for sub-marine cables, turbine tower flange, etc.) is attached to the driven pile, and the sand and water are removed from the centre of the pile and replaced with concrete. An additional layer of even larger stone, up to 0.5 m diameter, is applied to the surface of the seabed for longer-term erosion protection.[2]

Drilled piles

[edit]

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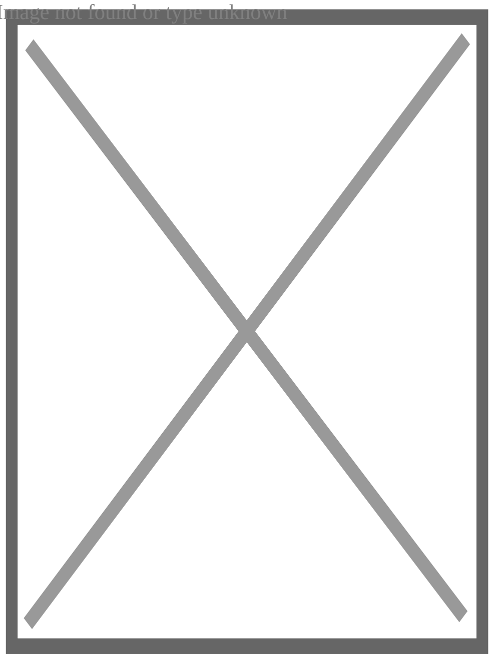

A pile machine in Amsterdam.

Also called **caissons**, **drilled shafts**, **drilled piers**, **cast-in-drilled-hole piles (CIDH piles)** or **cast-in-situ** piles, a borehole is drilled into the ground, then concrete (and often some sort of reinforcing) is placed into the borehole to form the pile. Rotary boring techniques allow larger diameter piles than any other piling method and permit pile construction through particularly dense or hard strata. Construction methods depend on the geology of the site; in particular, whether boring is to be undertaken in 'dry' ground conditions or through water-saturated strata. Casing is often used when the sides of the borehole are likely to slough off before concrete is poured.

For end-bearing piles, drilling continues until the borehole has extended a sufficient depth (socketing) into a sufficiently strong layer. Depending on site geology, this can be a rock layer, or hardpan, or other dense, strong layers. Both the diameter of the pile and the depth of the pile are highly specific to the ground conditions, loading conditions, and nature of the project. Pile depths may vary substantially across a project if the bearing layer is not level. Drilled piles can be tested using a variety of methods to verify the pile integrity during installation.

Under-reamed piles

[edit]

Under-reamed piles have mechanically formed enlarged bases that are as much as 6 m in diameter.[*citation needed*] The form is that of an inverted cone and can only be formed in stable soils or rocks. The larger base diameter allows greater bearing capacity than a straight-shaft pile.

These piles are suited for expansive soils which are often subjected to seasonal moisture variations, or for loose or soft strata. They are used in normal ground condition also where economics are favorable. [5][*full citation needed*]

Under reamed piles foundation is used for the following soils:-

1. Under reamed piles are used in black cotton soil: This type of soil expands when it comes in contact with water and contraction occurs when water is removed. So that cracks appear in the construction done on such clay. An under reamed pile is used in the base to remove this defect.

2. Under reamed piles are used in low bearing capacity Outdated soil (filled soil)

3.Under reamed piles are used in sandy soil when water table is high.

4. Under reamed piles are used, Where lifting forces appear at the base of foundation.

Augercast pile

[edit]

An augercast pile, often known as a continuous flight augering (CFA) pile, is formed by drilling into the ground with a hollow stemmed continuous flight auger to the required depth or degree of resistance. No casing is required. A cement grout mix is then pumped down the stem of the auger. While the cement grout is pumped, the auger is slowly withdrawn, conveying the soil upward along the flights. A shaft of fluid cement grout is formed to ground level. Reinforcement can be installed. Recent innovations in addition to stringent quality control allows reinforcing cages to be placed up to the full length of a pile when required.[*citation needed*]

Augercast piles cause minimal disturbance and are often used for noise-sensitive and environmentally-sensitive sites. Augercast piles are not generally suited for use in contaminated soils, because of expensive waste disposal costs. In cases such as these, a displacement pile (like Olivier piles) may provide the cost efficiency of an augercast pile and minimal environmental impact. In ground containing obstructions or cobbles and boulders, augercast piles are less suitable as refusal above the design pile tip elevation may be encountered.[*citation needed*]

Small Sectional Flight Auger piling rigs can also be used for piled raft foundations. These produce the same type of pile as a Continuous Flight Auger rig but using smaller, more lightweight equipment. This piling method is fast, cost-effective and suitable for the majority of ground types.[5][6]

Pier and grade beam foundation

[edit]

In drilled pier foundations, the piers can be connected with grade beams on which the structure sits, sometimes with heavy column loads bearing directly on the piers. In some residential construction, the piers are extended above the ground level, and wood beams bearing on the piers are used to support the structure. This type of foundation results in a crawl space underneath the building in which wiring and duct work can be laid during construction or re-modelling.[7]

Speciality piles

[edit]

Jet-piles

[edit]

In jet piling high pressure water is used to set piles.[8] High pressure water cuts through soil with a high-pressure jet flow and allows the pile to be fitted.[9] One advantage of Jet Piling: the water jet lubricates the pile and softens the ground.[10] The method is in use in Norway.[11]

Micropiles

[edit]

Micropiles are small diameter, generally less than 300mm diameter, elements that are drilled and grouted in place. They typically get their capacity from skin friction along the sides of the element, but can be end bearing in hard rock as well. Micropiles are usually heavily reinforced with steel comprising more than 40% of their cross section. They can be used as direct structural support or as ground reinforcement elements. Due to their relatively high cost and the type of equipment used to install these elements, they are often used where access restrictions and or very difficult ground conditions (cobbles and boulders, construction debris, karst, environmental sensitivity) exists or to retrofit existing structures. Occasionally, in difficult ground, they are used for new construction foundation elements. Typical applications include underpinning, bridge, transmission tower and slope stabilization projects.[6][12][13][14]

Tripod piles

[edit]

The use of a tripod rig to install piles is one of the more traditional ways of forming piles. Although unit costs are generally higher than with most other forms of piling,[*citation needed*] it has several advantages which have ensured its continued use through to the present day. The tripod system is easy and inexpensive to bring to site, making it ideal for jobs with a small number of piles.[*clarification needed*]

Sheet piles

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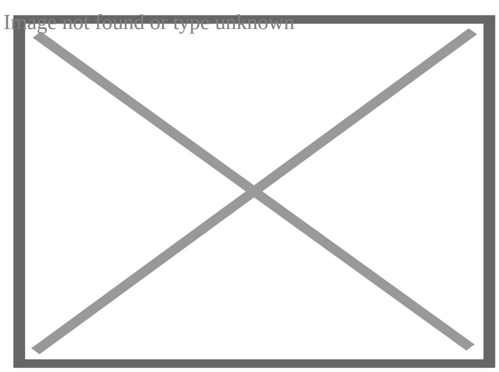
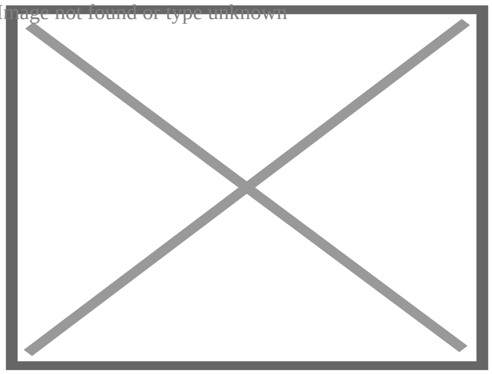


Sheet piles are used to restrain soft soil above the bedrock in this excavation

Sheet piling is a form of driven piling using thin interlocking sheets of steel to obtain a continuous barrier in the ground. The main application of sheet piles is in retaining walls and cofferdams erected to enable permanent works to proceed. Normally, vibrating hammer, t-crane and crawle drilling are used to establish sheet piles.[*citation needed*]

Soldier piles

[edit]



A soldier pile wall using reclaimed railway sleepers as lagging.

Soldier piles, also known as king piles or Berlin walls, are constructed of steel H sections spaced about 2 to 3 m apart and are driven or drilled prior to excavation. As the excavation proceeds, horizontal timber sheeting (lagging) is inserted behind the H pile flanges.

The horizontal earth pressures are concentrated on the soldier piles because of their relative rigidity compared to the lagging. Soil movement and subsidence is minimized by installing the lagging immediately after excavation to avoid soil loss.[*citation needed*] Lagging can be constructed by timber, precast concrete, shotcrete and steel plates depending on spacing of the soldier piles and the type of soils.

Soldier piles are most suitable in conditions where well constructed walls will not result in subsidence such as over-consolidated clays, soils above the water table if they have some cohesion, and free draining soils which can be effectively dewatered, like sands.[*citation n*

Unsuitable soils include soft clays and weak running soils that allow large movements such as loose sands. It is also not possible to extend the wall beyond the bottom of the excavation, and dewatering is often required.[*citation needed*]

Screw piles

[edit]

Screw piles, also called *helical piers* and *screw foundations*, have been used as foundations since the mid 19th century in screw-pile lighthouses.[*citation needed*] Screw piles are galvanized iron pipe with helical fins that are turned into the ground by machines to the required depth. The screw distributes the load to the soil and is sized accordingly.

Suction piles

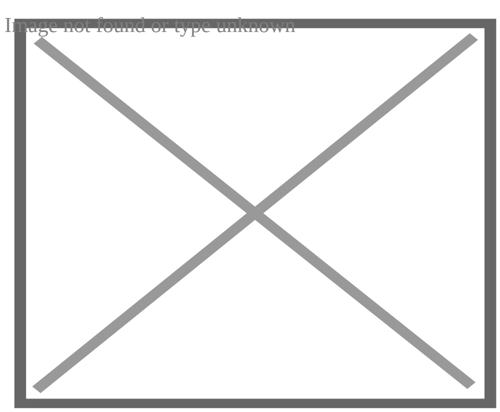
[edit]

Suction piles are used underwater to secure floating platforms. Tubular piles are driven into the seabed (or more commonly dropped a few metres into a soft seabed) and then a pump sucks water out at the top of the tubular, pulling the pile further down.

The proportions of the pile (diameter to height) are dependent upon the soil type. Sand is difficult to penetrate but provides good holding capacity, so the height may be as short as half the diameter. Clays and muds are easy to penetrate but provide poor holding capacity, so the height may be as much as eight times the diameter. The open nature of gravel means that water would flow through the ground during installation, causing 'piping' flow (where water boils up through weaker paths through the soil). Therefore, suction piles cannot be used in gravel seabeds.[*citation needed*]

Adfreeze piles

[edit]



Adfreeze piles supporting a building in UtqiaÃƒâ€žÃ‚Â¡vik, Alaska

In high latitudes where the ground is continuously frozen, adfreeze piles are used as the primary structural foundation method.

Adfreeze piles derive their strength from the bond of the frozen ground around them to the surface of the pile.[*citation needed*]

Adfreeze pile foundations are particularly sensitive in conditions which cause the permafrost to melt. If a building is constructed improperly then it can melt the ground below, resulting in a failure of the foundation system.[*citation needed*]

Vibrated stone columns

[edit]

Vibrated stone columns are a ground improvement technique where columns of coarse aggregate are placed in soils with poor drainage or bearing capacity to improve the soils.[*citation needed*]

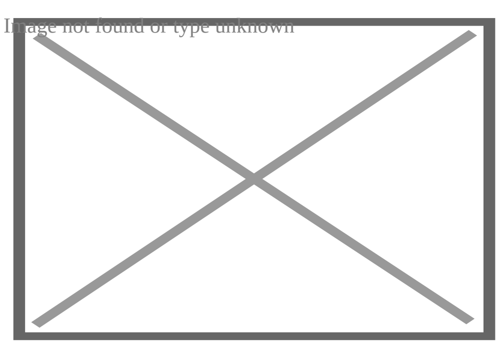
Hospital piles

[edit]

Specific to marine structures, hospital piles (also known as gallow piles) are built to provide temporary support to marine structure components during refurbishment works. For example, when removing a river pontoon, the brow will be attached to hospital pile to support it. They are normal piles, usually with a chain or hook attachment.[*citation needed*]

Piled walls

[edit]



Sheet piling, by a bridge, was used to block a canal in New Orleans after Hurricane Katrina damaged it.

Piled walls can be drivene or bored. They provide special advantages where available working space dictates and open cut excavation not feasible. Both methods offer technically effective and offer a cost efficient temporary or permanent means of retaining the sides of bulk excavations even in water bearing strata. When used in permanent works, these walls can be designed to resist vertical loads in addition lateral load from retaining soil. Construction of both methods is the same as for foundation bearing piles. Contiguous walls are constructed with small gaps between adjacent piles. The spacing of the piles can be varied to provide suitable bending stiffness.

Secant piled walls

[edit]

Secant pile walls are constructed such that space is left between alternate 'female' piles for the subsequent construction of 'male' piles.[*clarification needed*] Construction of 'male' piles involves boring through the concrete in the 'female' piles hole in order to key 'male' piles between. The male pile is the one where steel reinforcement cages are installed, though in some cases the female piles are also reinforced.[*citation needed*]

Secant piled walls can either be true hard/hard, hard/intermediate (firm), or hard/soft, depending on design requirements. Hard refers to structural concrete and firm or soft is usually a weaker grout mix containing bentonite.[*citation needed*] All types of wall can be constructed as free standing cantilevers, or may be propped if space and sub-structure design permit. Where party wall agreements allow, ground anchors can be used as tie backs.

Slurry walls

[edit]

A slurry wall is a barrier built under ground using a mix of bentonite and water to prevent the flow of groundwater. A trench that would collapse due to the hydraulic pressure in the surrounding soil does not collapse as the slurry balances the hydraulic pressure.

Deep mixing/mass stabilization techniques

[edit]

These are essentially variations of *in situ* reinforcements in the form of piles (as mentioned above), blocks or larger volumes.

Cement, lime/quick lime, flyash, sludge and/or other binders (sometimes called stabilizer) are mixed into the soil to increase bearing capacity. The result is not as solid as concrete, but should be seen as an improvement of the bearing capacity of the original soil.

The technique is most often applied on clays or organic soils like peat. The mixing can be carried out by pumping the binder into the soil whilst mixing it with a device normally mounted on an excavator or by excavating the masses, mixing them separately with the binders and refilling them in the desired area. The technique can also be used on lightly contaminated masses as a means of binding contaminants, as opposed to excavating them and transporting to landfill or processing.

Materials

[edit]

Timber

[edit]
Main article: Timber pilings

As the name implies, timber piles are made of wood.

Historically, timber has been a plentiful, locally available resource in many areas. Today, timber piles are still more affordable than concrete or steel. Compared to other types of piles (steel or concrete), and depending on the source/type of timber, timber piles may not be suitable for heavier loads.

A main consideration regarding timber piles is that they should be protected from rotting above groundwater level. Timber will last for a long time below the groundwater level. For timber to rot, two elements are needed: water and oxygen. Below the groundwater level, dissolved oxygen is lacking even though there is ample water. Hence, timber tends to last for a long time below the groundwater level. An example is Venice, which has had timber pilings since its beginning; even most of the oldest piles are still in use. In 1648, the Royal Palace of Amsterdam was constructed on 13,659 timber piles that still survive today since they were below groundwater level. Timber that is to be used above the water table can be protected from decay and insects by numerous forms of wood preservation using pressure treatment (alkaline copper quaternary (ACQ), chromated copper arsenate (CCA), creosote, etc.).

Splicing timber piles is still quite common and is the easiest of all the piling materials to splice. The normal method for splicing is by driving the leader pile first, driving a steel tube (normally 60–100 cm long, with an internal diameter no smaller than the minimum toe diameter) half its length onto the end of the leader pile. The follower pile is then simply slotted into the other end of the tube and driving continues. The steel tube is simply there to ensure that the two pieces follow each other during driving. If uplift capacity is required, the splice can incorporate bolts, coach screws, spikes or the like to give it the necessary capacity.

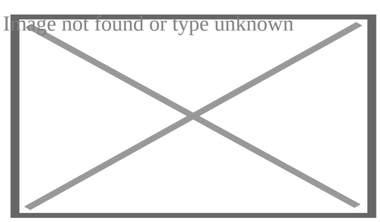
Iron

[edit]

Cast iron may be used for piling. These may be ductile.[*citation needed*]

Steel

[edit]



Cutaway illustration. Deep inclined (battered) pipe piles support a precast segmented skyway where upper soil layers are weak muds.

Pipe piles are a type of steel driven pile foundation and are a good candidate for inclined (battered) piles.

Pipe piles can be driven either open end or closed end. When driven open end, soil is allowed to enter the bottom of the pipe or tube. If an empty pipe is required, a jet of water or an auger can be used to remove the soil inside following driving. Closed end pipe piles are constructed by covering the bottom of the pile with a steel plate or cast steel shoe.

In some cases, pipe piles are filled with concrete to provide additional moment capacity or corrosion resistance. In the United Kingdom, this is generally not done in order to reduce the cost.[*citation needed*] In these cases corrosion protection is provided by allowing for a sacrificial thickness of steel or by adopting a higher grade of steel. If a concrete filled pipe pile is corroded, most of the load carrying capacity of the pile will remain intact due to the concrete, while it will be lost in an empty pipe pile. The structural capacity of pipe piles is primarily calculated based on steel strength and concrete strength (if filled). An allowance is made for corrosion depending on the site conditions and local building codes. Steel pipe piles can either be new steel manufactured specifically for the piling industry or reclaimed steel tubular casing previously used for other purposes such as oil and gas exploration.

H-Piles are structural beams that are driven in the ground for deep foundation application. They can be easily cut off or joined by welding or mechanical drive-fit splicers. If the pile is driven into a soil with low pH value, then there is a risk of corrosion, coal-tar epoxy or cathodic protection can be applied to slow or eliminate the corrosion process. It is common to allow for an amount of corrosion in design by simply over dimensioning the cross-sectional area of the steel pile. In this way, the corrosion process can be prolonged up to 50 years.[*citation needed*]

Prestressed concrete piles

[edit]

Concrete piles are typically made with steel reinforcing and prestressing tendons to obtain the tensile strength required, to survive handling and driving, and to provide sufficient bending resistance.

Long piles can be difficult to handle and transport. Pile joints can be used to join two or more short piles to form one long pile. Pile joints can be used with both precast and prestressed concrete piles.

Composite piles

[edit]

A "composite pile" is a pile made of steel and concrete members that are fastened together, end to end, to form a single pile. It is a combination of different materials or different shaped materials such as pipe and H-beams or steel and concrete.

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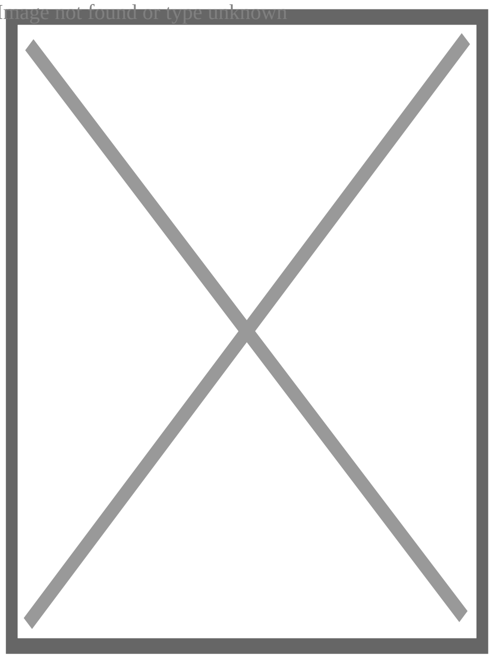

'Pile jackets' encasing old concrete piles in a saltwater environment to prevent corrosion and consequential weakening of the piles when cracks allow saltwater to contact the internal steel reinforcement rods

Construction machinery for driving piles into the ground

[edit]

Construction machinery used to drive piles into the ground:[15]

- Pile driver is a device for placing piles in their designed position.
- Diesel pile hammer is a device for hammering piles into the ground.
- Hydraulic hammer is removable working equipment of hydraulic excavators, hydroficated machines (stationary rock breakers, loaders, manipulators, pile driving hammers) used for processing strong materials (rock, soil, metal) or pile driving elements by impact of falling parts dispersed by high-pressure fluid.
- Vibratory pile driver is a machine for driving piles into sandy and clay soils.
- Press-in pile driver is a machine for sinking piles into the ground by means of static force transmission.[16]
- Universal drilling machine.

Construction machinery for replacement piles

[edit]

Construction machinery used to construct replacement piles:[15]

- Sectional Flight Auger or Continuous Flight Auger
- Reverse circulation drilling
- Ring bit concentric drilling

See also

[edit]
- Eurocode EN 1997
- International Society for Micropiles
- Post in ground construction also called earthfast or posthole construction; a historic method of building wooden structures.
- Stilt house, also known as a lake house; an ancient, historic house type built on pilings.
- Shallow foundations
- Pile bridge
- Larssen sheet piling

Notes

[edit]

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External links

[edit]

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Wikimedia Commons has media related to ***Deep foundations***.

- Deep Foundations Institute

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- e

Geotechnical engineering

Offshore geotechnical engineering

Investigation and instrumentation

- Field (*in situ*)
  - Core drill
  - Cone penetration test
  - Geo-electrical sounding
  - Permeability test
  - Load test
    - Static
    - Dynamic
    - Statnamic
  - Pore pressure measurement
    - Piezometer
    - Well
  - Ram sounding
  - Rock control drilling
  - Rotary-pressure sounding
  - Rotary weight sounding
  - Sample series
  - Screw plate test
  - Deformation monitoring
    - Inclinometer
    - Settlement recordings
  - Shear vane test
  - Simple sounding
  - Standard penetration test
  - Total sounding
  - Trial pit
  - Visible bedrock
  - Nuclear densometer test
  - Exploration geophysics
  - Crosshole sonic logging
  - Pile integrity test
  - Wave equation analysis
- Laboratory testing
  - Soil classification
  - Atterberg limits
  - California bearing ratio
  - Direct shear test
  - Hydrometer
  - Proctor compaction test
  - R-value
  - Sieve analysis
  - Triaxial shear test
  - Oedometer test
  - Hydraulic conductivity tests
  - Water content tests

Soil

- Types
  - Clay
  - Silt
  - Sand
  - Gravel
  - Peat
  - Loam
  - Loess
- Properties
  - Hydraulic conductivity
  - Water content
  - Void ratio
  - Bulk density
  - Thixotropy
  - Reynolds' dilatancy
  - Angle of repose
  - Friction angle
  - Cohesion
  - Porosity
  - Permeability
  - Specific storage
  - Shear strength
  - Sensitivity

Structures (Interaction)

- Natural features
  - Topography
  - Vegetation
  - Terrain
  - Topsoil
  - Water table
  - Bedrock
  - Subgrade
  - Subsoil
  - Shoring structures
    - Retaining walls
    - Gabion
    - Ground freezing
    - Mechanically stabilized earth
    - Pressure grouting
    - Slurry wall
    - Soil nailing
    - Tieback
- Earthworks
  - Land development
  - Landfill
  - Excavation
  - Trench
  - Embankment
  - Cut
  - Causeway
  - Terracing
  - Cut-and-cover
  - Cut and fill
  - Fill dirt
  - Grading
  - Land reclamation
  - Track bed
  - Erosion control
  - Earth structure
  - Expanded clay aggregate
  - Crushed stone
  - Geosynthetics
    - Geotextile
    - Geomembrane
    - Geosynthetic clay liner
    - Cellular confinement
  - Infiltration
- Foundations
  - Shallow
  - Deep

Mechanics	Forces	○ Effective stress ○ Pore water pressure ○ Lateral earth pressure ○ Overburden pressure ○ Preconsolidation pressure

	Phenomena/ problems	○ Permafrost
		○ Frost heaving
		○ Consolidation
		○ Compaction
		○ Earthquake
		    ○ Response spectrum
		    ○ Seismic hazard
		    ○ Shear wave
		○ Landslide analysis
		    ○ Stability analysis
		    ○ Mitigation
		    ○ Classification
		    ○ Sliding criterion
		    ○ Slab stabilisation
		○ Bearing capacity * Stress distribution in soil

Numerical analysis software	○ SEEP2D ○ STABL ○ SVFlux ○ SVSlope ○ UTEXAS ○ Plaxis	
Related fields	○ Geology ○ Geochemistry ○ Petrology ○ Earthquake engineering ○ Geomorphology ○ Soil science ○ Hydrology ○ Hydrogeology ○ Biogeography ○ Earth materials ○ Archaeology ○ Agricultural science ○ Agrology	

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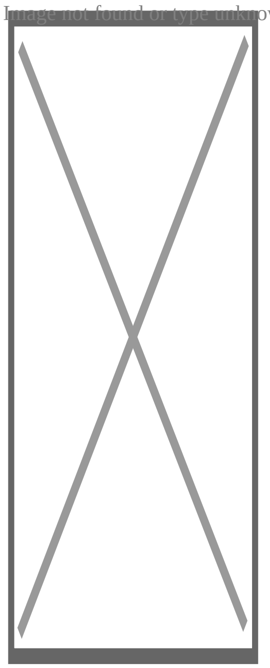
About Carbon-fiber reinforced polymer

"Carbon fiber" redirects here. For fibers of carbon, see **Carbon fibers**.



Tail of a **radio-controlled helicopter**, made of CFRP

Carbon fiber-reinforced polymers (**American English**), **carbon-fibre-reinforced polymers** (**Commonwealth English**), **carbon-fiber-reinforced plastics**, **carbon-fiber reinforced-thermoplastic** (**CFRP**, **CRP**, **CFRTP**), also known as **carbon fiber**, **carbon composite**, or just **carbon**, are extremely strong and light **fiber-reinforced plastics** that contain **carbon fibers**. CFRPs can be expensive to produce, but are commonly used wherever high **strength-to-weight ratio** and **stiffness** (rigidity) are required, such as aerospace, superstructures of ships, automotive, civil engineering, sports equipment, and an increasing number of consumer and technical applications.[1][2][3][4]

The binding **polymer** is often a **thermoset** resin such as **epoxy**, but other thermoset or **thermoplastic** polymers, such as **polyester**, **vinyl ester**, or **nylon**, are sometimes used.[4] The properties of the final CFRP product can be affected by the type of additives introduced to the binding matrix (resin). The most common additive is **silica**, but other additives such as rubber and **carbon nanotubes** can be used.

Carbon fiber is sometimes referred to as *graphite-reinforced polymer* or *graphite fiber-reinforced polymer* (*GFRP* is less common, as it clashes with **glass-(fiber)-reinforced polymer**).

Properties

[**edit**]

CFRP are **composite materials**. In this case the composite consists of two parts: a matrix and a reinforcement. In CFRP the reinforcement is carbon fiber, which provides its strength. The matrix is usually a thermosetting plastic, such as polyester resin, to bind the reinforcements together.[5] Because CFRPs consist of two distinct elements, the material properties depend on these two elements.

Reinforcement gives CFRPs their strength and rigidity, measured by **stress** and **elastic modulus** respectively. Unlike **isotropic** materials like steel and aluminum, CFRPs have directional strength properties. The properties of a CFRP depend on the layouts of the carbon fiber and the proportion of the carbon fibers relative to the polymer.[6] The two different equations governing the net elastic modulus of composite materials using the properties of the carbon fibers and the polymer matrix can also be applied to carbon fiber reinforced plastics.[7] The **rule of mixtures** for the equal **strain** case gives:

$$\displaystyle E_c=V_mE_m+V_fE_f$$

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which is valid for composite materials with the fibers oriented **parallel** to the applied load. E_c is the total composite modulus, V_m and V_f are the volume fractions of the matrix and fiber respectively in the composite, and E_m and E_f are the elastic moduli of the matrix and fibers respectively.[7] The other extreme case of the elastic modulus of the composite with the fibers oriented transverse to the applied load can be found using the inverse rule of mixtures for the equal stress case:[7]

$$\displaystyle E_c=\left(\frac{V_m}{E_m}+\frac{V_f}{E_f}\right)^{-1}$$

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The above equations give an upper and lower bound on the Young's modulus for CFRP and there are many other factors that influence the true value.

The fracture toughness of carbon fiber reinforced plastics is governed by multiple mechanisms:

- Debonding between the carbon fiber and polymer matrix.
- Fiber pull-out.
- Delamination between the CFRP sheets.[8]

Typical epoxy-based CFRPs exhibit virtually no plasticity, with less than 0.5% strain to failure. Although CFRPs with epoxy have high strength and elastic modulus, the brittle fracture mechanics presents unique challenges to engineers in failure detection since failure occurs catastrophically.[8] As such, recent efforts to toughen CFRPs include modifying the existing epoxy material and finding alternative polymer matrix. One such material with high promise is **PEEK**, which exhibits an order of magnitude greater toughness with similar elastic modulus and tensile strength.[8] However, PEEK is much more difficult to process and more expensive.[8]

Despite their high initial strength-to-weight ratios, a design limitation of CFRPs are their lack of a definable **fatigue limit**. This means, theoretically, that stress cycle failure cannot be ruled out. While steel and many other structural metals and alloys do have estimable fatigue or endurance limits, the complex failure modes of composites mean that the fatigue failure properties of CFRPs are difficult to predict and design against; however emerging research has shed light on the effects of low velocity impacts on composites.[9] Low velocity impacts can make carbon fiber polymers susceptible to damage.[9][10][11] As a result, when using CFRPs for critical cyclic-loading applications, engineers may need to design in considerable strength safety margins to provide suitable component reliability over its service life.

Environmental effects such as temperature and **humidity** can have profound effects on the polymer-based composites, including most CFRPs. While CFRPs demonstrate excellent corrosion resistance, the effect of moisture at wide ranges of temperatures can lead to degradation of the mechanical properties of CFRPs, particularly at the matrix-fiber interface.[12] While the carbon fibers themselves are not affected by the moisture diffusing into the material, the moisture plasticizes the polymer matrix.[8] This leads to significant changes in properties that are dominantly influenced by the matrix in CFRPs such as compressive, interlaminar shear, and impact properties.[13] The epoxy matrix used for engine fan blades is designed to be impervious against jet fuel, lubrication, and rain water, and external paint on the composites parts is applied to minimize damage from ultraviolet light.[8][14]

Carbon fibers can cause **galvanic corrosion** when CFRP parts are attached to aluminum or mild steel but not to stainless steel or titanium.[15]

CFRPs are very hard to machine, and cause significant tool wear. The tool wear in CFRP machining is dependent on the fiber orientation and machining condition of the cutting process. To reduce tool wear various types of coated tools are used in machining CFRP and CFRP-metal stack.[1]

Manufacturing

[edit]

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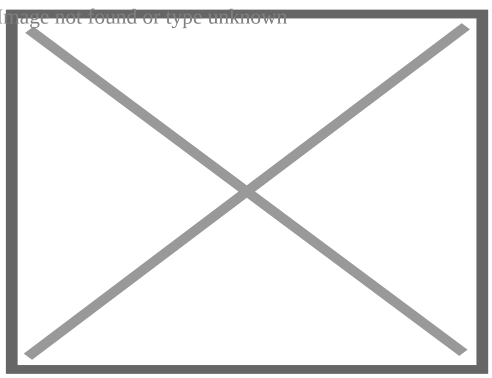


Carbon fiber reinforced polymer

The primary element of CFRPs is a **carbon filament**; this is produced from a precursor **polymer** such as **polyacrylonitrile** (PAN), **rayon**, or petroleum **pitch**. For synthetic polymers such as PAN or rayon, the precursor is first **spun** into filament yarns, using chemical and mechanical processes to initially align the polymer chains in a way to enhance the final physical properties of the completed carbon fiber. Precursor compositions and mechanical processes used during spinning filament yarns may vary among manufacturers. After drawing or spinning, the polymer filament yarns are then heated to drive off non-carbon atoms (**carbonization**), producing the final carbon fiber. The carbon fibers filament yarns may be further treated to improve handling qualities, then wound onto **bobbins**.[16] From these fibers, a unidirectional sheet is created. These sheets are layered onto each other in a quasi-isotropic layup, e.g. 0°, +60°, or ?60° relative to each other.

From the elementary fiber, a bidirectional woven sheet can be created, i.e. a **twill** with a 2/2 weave. The process by which most CFRPs are made varies, depending on the piece being created, the finish (outside gloss) required, and how many of the piece will be produced. In addition, the choice of matrix can have a profound effect on the properties of the finished composite.[17]

Many CFRP parts are created with a single layer of carbon fabric that is backed with fiberglass.[18] A tool called a chopper gun is used to quickly create these composite parts. Once a thin shell is created out of carbon fiber, the chopper gun cuts rolls of fiberglass into short lengths and sprays resin at the same time, so that the fiberglass and resin are mixed on the spot.[19] The resin is either external mix, wherein the hardener and resin are sprayed separately, or internal mixed, which requires cleaning after every use. Manufacturing methods may include the following:

Molding

[**edit**]

One method of producing CFRP parts is by layering sheets of carbon fiber cloth into a **mold** in the shape of the final product. The alignment and weave of the cloth fibers is chosen to optimize the strength and stiffness properties of the resulting material. The mold is then filled with **epoxy** and is heated or air-cured. The resulting part is very corrosion-resistant, stiff, and strong for its weight. Parts used in less critical areas are manufactured by draping cloth over a mold, with epoxy either pre-impregnated into the fibers (also known as ***pre-preg***) or "painted" over it. High-performance parts using single molds are often vacuum-bagged and/or **autoclave**-cured, because even small air bubbles in the material will reduce strength. An alternative to the autoclave method is to use internal pressure via inflatable air bladders or **EPS foam** inside the non-cured laid-up carbon fiber.

Vacuum bagging

[**edit**]

For simple pieces of which relatively few copies are needed (one or two per day), a **vacuum bag** can be used. A fiberglass, carbon fiber, or aluminum mold is polished and waxed, and has a **release agent** applied before the fabric and resin are applied, and the vacuum is pulled and set aside to allow the piece to cure (harden). There are three ways to apply the resin to the fabric in a vacuum mold.

The first method is manual and called a wet layup, where the two-part resin is mixed and applied before being laid in the mold and placed in the bag. The other one is done by infusion, where the dry fabric and mold are placed inside the bag while the vacuum pulls the resin through a small tube into the bag, then through a tube with holes or something similar to evenly spread the resin throughout the fabric. Wire loom works perfectly for a tube that requires holes inside the bag. Both of these methods of applying resin require hand work to spread the resin evenly for a glossy finish with very small pin-holes.

A third method of constructing composite materials is known as a dry layup. Here, the carbon fiber material is already impregnated with resin (pre-preg) and is applied to the mold in a similar fashion to adhesive film. The assembly is then placed in a vacuum to cure. The dry layup method has the least amount of resin waste and can achieve lighter constructions than wet layup. Also, because larger amounts of resin are more difficult to bleed out with wet layup methods, pre-preg parts generally have fewer pinholes. Pinhole elimination with minimal resin amounts generally require the use of **autoclave** pressures to purge the residual gases out.

Compression molding

[**edit**]

A quicker method uses a **compression mold**, also commonly known as carbon fiber forging. This is a two (male and female), or multi-piece mold, usually made out of aluminum or steel and more recently 3D printed plastic. The mold components are pressed together with the fabric and resin loaded into the inner cavity that ultimately becomes the desired component. The benefit is the speed of the entire process. Some car manufacturers, such as BMW, claimed to be able to cycle a new part every 80 seconds. However, this technique has a very high initial cost since the molds require CNC machining of very high precision.

Filament winding

[**edit**]

For difficult or convoluted shapes, a **filament winder** can be used to make CFRP parts by winding filaments around a mandrel or a core.

Cutting

[edit]

Carbon fiber-reinforced **pre-pregs** and dry carbon fiber textiles require precise cutting methods to maintain material integrity and reduce defects such as fiber pull-out, **delamination** and fraying of the cutting edge. **CNC digital cutting systems** equipped with drag and oscillating are often used to cut carbon fiber pre-pregs, and rotating knives are commonly used to process carbon fiber fabrics. **Ultrasonic** cutting is another method to cut CFRP pre-pregs and is particularly effective in reducing delamination by minimizing **mechanical stress** during the cutting process. **Waterjet cutting** can be the preferred method for thicker and multilayered polymer **composites**.**[20]**

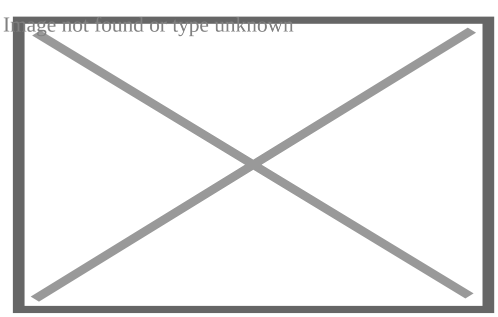
Applications

[edit]

Applications for CFRPs include the following:

Aerospace engineering

[edit]



An **Airbus A350** with carbon fiber themed **livery**. Composite materials are used extensively throughout the A350.

The **Airbus A350 XWB** is 53% CFRP**[21]** including wing spars and fuselage components, overtaking the **Boeing 787 Dreamliner**, for the aircraft with the highest weight ratio for CFRP at 50%.**[22]** It was one of the first commercial aircraft to have wing spars made from composites. The **Airbus A380** was one of the first commercial airliners to have a central wing-box made of CFRP and the first with a smoothly contoured wing cross-section instead of partitioning it span-wise into sections. This flowing, continuous cross section optimises aerodynamic efficiency.[***citation needed***] Moreover, the trailing edge, along with the rear bulkhead, **empennage**, and un-pressurised fuselage are made of CFRP.**[23]**

However, delays have pushed order delivery dates back because of manufacturing problems. Many aircraft that use CFRPs have experienced delays with delivery dates due to the relatively new processes used to make CFRP components, whereas metallic structures are better understood. A recurrent problem is the monitoring of structural ageing, for which new methods are required, due to the unusual multi-material and anisotropic**[24][25][26]** nature of CFRPs.**[27]**

In 1968 a *Hyfil* carbon-fiber fan assembly was in service on the **Rolls-Royce Conways** of the **Vickers VC10s** operated by **BOAC**.**[28]**

Specialist aircraft designers and manufacturers **Scaled Composites** have made extensive use of CFRPs throughout their design range, including the first private crewed spacecraft **Spaceship One**. CFRPs are widely used in **micro air vehicles** (MAVs) because of their high strength-to-weight ratio.

Airbus then moved to adopt CFRTP, because it can be reshaped and reprocessed after forming, can be manufactured faster, has higher impact resistance, is recyclable and remoldable, and has lower processing costs.**[29]**

Automotive engineering

[**edit**]

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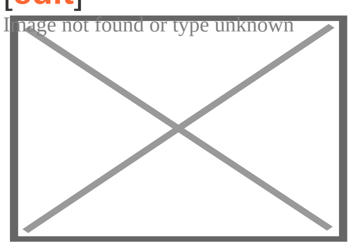
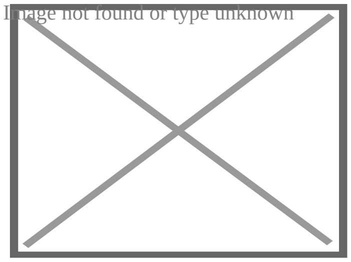
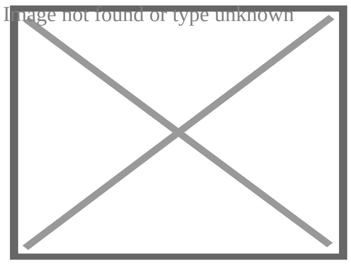


Citroën SM that won 1971 **Rally of Morocco** with carbon fiber wheels



1996 **McLaren F1** – first carbon fiber body shell



McLaren MP4 (MP4/1), first carbon fiber F1 car

CFRPs are extensively used in high-end automobile racing.[30] The high cost of carbon fiber is mitigated by the material's unsurpassed strength-to-weight ratio, and low weight is essential for high-performance automobile racing. Race-car manufacturers have also developed methods to give carbon fiber pieces strength in a certain direction, making it strong in a load-bearing direction, but weak in directions where little or no load would be placed on the member. Conversely, manufacturers developed omnidirectional carbon fiber weaves that apply strength in all directions. This type of carbon fiber assembly is most widely used in the "safety cell" **monocoque** chassis assembly of high-performance race-cars. The first carbon fiber monocoque chassis was introduced in **Formula One** by **McLaren** in the 1981 season. It was designed by **John Barnard** and was widely copied in the following seasons by other F1 teams due to the extra rigidity provided to the chassis of the cars.[31]

Many **supercars** over the past few decades have incorporated CFRPs extensively in their manufacture, using it for their monocoque chassis as well as other components.[32] As far back as 1971, the **Citroën SM** offered optional lightweight carbon fiber wheels.[33][34]

Use of the material has been more readily adopted by low-volume manufacturers who used it primarily for creating body-panels for some of their high-end cars due to its increased strength and decreased weight compared with the **glass-reinforced polymer** they used for the majority of their products.

Civil engineering

[edit]
Further information: Structural applications of FRP

CFRPs have become a notable material in structural engineering applications. Studied in an academic context as to their potential benefits in construction, CFRPs have also proved themselves cost-effective in a number of field applications strengthening concrete, masonry, steel, cast iron, and timber structures. Their use in industry can be either for retrofitting to strengthen an existing structure or as an alternative reinforcing (or prestressing) material instead of steel from the outset of a project.

Retrofitting has become the increasingly dominant use of the material in civil engineering, and applications include increasing the load capacity of old structures (such as bridges, beams, ceilings, columns and walls) that were designed to tolerate far lower service loads than they are experiencing today, seismic retrofitting, and repair of damaged structures. Retrofitting is popular in many instances as the cost of replacing the deficient structure can greatly exceed the cost of strengthening using CFRP.[35]

Applied to reinforced concrete structures for flexure, the use of CFRPs typically has a large impact on strength (doubling or more the strength of the section is not uncommon), but only moderately increases stiffness (as little as 10%). This is because the material used in such applications is typically very strong (e.g., 3 GPa ultimate tensile strength, more than 10 times mild steel) but not particularly stiff (150 to 250 GPa elastic modulus, a little less than steel, is typical). As a consequence, only small cross-sectional areas of the material are used. Small areas of very high strength but moderate stiffness material will significantly increase strength, but not stiffness.

CFRPs can also be used to enhance shear strength of reinforced concrete by wrapping fabrics or fibers around the section to be strengthened. Wrapping around sections (such as bridge or building columns) can also enhance the ductility of the section, greatly increasing the resistance to collapse under dynamic loading. Such 'seismic retrofit' is the major application in earthquake-prone areas, since it is much more economic than alternative methods.

If a column is circular (or nearly so) an increase in axial capacity is also achieved by wrapping. In this application, the confinement of the CFRP wrap enhances the compressive strength of the concrete. However, although large increases are achieved in the ultimate collapse load, the concrete will crack at only slightly enhanced load, meaning that this application is only occasionally used. Specialist ultra-high modulus CFRP (with tensile modulus of 420 GPa or more) is one of the few practical methods of strengthening **cast iron** beams. In typical use, it is bonded to the tensile flange of the section, both increasing the stiffness of the section and lowering the **neutral axis**, thus greatly reducing the maximum tensile stress in the cast iron.

In the United States, **prestressed concrete** cylinder pipes (PCCP) account for a vast majority of water transmission mains. Due to their large diameters, failures of PCCP are usually catastrophic and affect large populations. Approximately 19,000 miles (31,000 km) of PCCP were installed between 1940 and 2006. **Corrosion** in the form of hydrogen embrittlement has been blamed for the gradual deterioration of the prestressing wires in many PCCP lines. Over the past decade, CFRPs have been used to internally line PCCP, resulting in a fully structural strengthening system. Inside a PCCP line, the CFRP liner acts as a barrier that controls the level of strain experienced by the steel cylinder in the host pipe. The composite liner enables the steel cylinder to perform within its elastic range, to ensure the pipeline's long-term performance is maintained. CFRP liner designs are based on strain compatibility between the liner and host pipe.**[36]**

CFRPs are more costly materials than commonly used their counterparts in the construction industry, **glass fiber-reinforced polymers** (GFRPs) and **aramid** fiber-reinforced polymers (AFRPs), though CFRPs are, in general, regarded as having superior properties. Much research continues to be done on using CFRPs both for retrofitting and as an alternative to steel as reinforcing or prestressing materials. Cost remains an issue and long-term **durability** questions still remain. Some are concerned about the **brittle** nature of CFRPs, in contrast to the ductility of steel. Though design codes have been drawn up by institutions such as the **American Concrete Institute**, there remains some hesitation among the engineering community about implementing these alternative materials. In part, this is due to a lack of standardization and the proprietary nature of the fiber and resin combinations on the market.

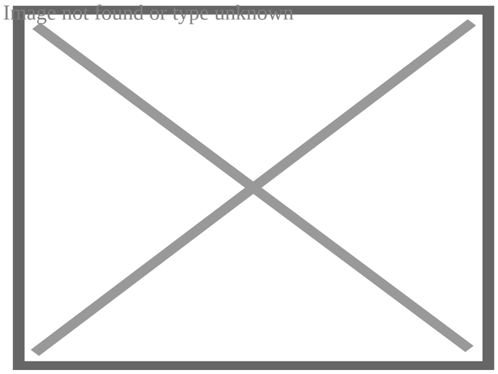
Carbon-fiber microelectrodes

[**edit**]

Carbon fibers are used for fabrication of carbon-fiber **microelectrodes**. In this application typically a single carbon fiber with diameter of 5–7 ?m is sealed in a glass capillary.**[37]** At the tip the capillary is either sealed with epoxy and polished to make carbon-fiber disk microelectrode or the fiber is cut to a length of 75–150 ?m to make carbon-fiber cylinder electrode. Carbon-fiber microelectrodes are used either in **amperometry** or **fast-scan cyclic voltammetry** for detection of biochemical signalling.

Sports goods

[edit]



A carbon-fiber and **Kevlar** canoe (Placid Boatworks Rapidfire at the **Adirondack Canoe Classic**)

CFRPs are now widely used in sports equipment such as in squash, tennis, and badminton racquets, **sport kite** spars, high-quality arrow shafts, hockey sticks, fishing rods, **surfboards**, high end swim fins, and rowing **shells**. Amputee athletes such as **Jonnie Peacock** use carbon fiber blades for running. It is used as a shank plate in some **basketball** sneakers to keep the foot stable, usually running the length of the shoe just above the sole and left exposed in some areas, usually in the arch.

Controversially, in 2006, cricket bats with a thin carbon-fiber layer on the back were introduced and used in competitive matches by high-profile players including **Ricky Ponting** and **Michael Hussey**. The carbon fiber was claimed to merely increase the durability of the bats, but it was banned from all first-class matches by the **ICC** in 2007.**[38]**

A CFRP **bicycle frame** weighs less than one of steel, aluminum, or **titanium** having the same strength. The type and orientation of the carbon-fiber weave can be designed to maximize stiffness in required directions. Frames can be tuned to address different riding styles: sprint events require stiffer frames while endurance events may require more flexible frames for rider comfort over longer periods.**[39]** The variety of shapes it can be built into has further increased stiffness and also allowed **aerodynamic** tube sections. CFRP **forks** including suspension fork crowns and steerers, **handlebars**, **seatposts**, and **crank arms** are becoming more common on medium as well as higher-priced bicycles. CFRP **rims** remain expensive but their stability compared to aluminium reduces the need to re-true a wheel and the reduced mass reduces the **moment of inertia** of the wheel. CFRP spokes are rare and most carbon wheelsets retain traditional stainless steel spokes. CFRPs also appear increasingly in other components such as derailleur parts, brake and shifter levers and bodies, cassette sprocket carriers, suspension linkages, disc brake rotors, pedals, shoe soles, and saddle rails. Although strong and light, impact, over-torquing, or improper installation of CFRP components has resulted in cracking and failures, which may be difficult or impossible to repair.[40][41]

Other applications

[**edit**]

Dunlop "Max-Grip" carbon fiber guitar picks. Sizes 1mm and Jazz III.

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Dunlop "Max-Grip" carbon fiber guitar picks. Sizes 1mm and Jazz III.

The fire resistance of polymers and thermo-set composites is significantly improved if a thin layer of carbon fibers is moulded near the surface because a dense, compact layer of carbon fibers efficiently reflects heat.[42]

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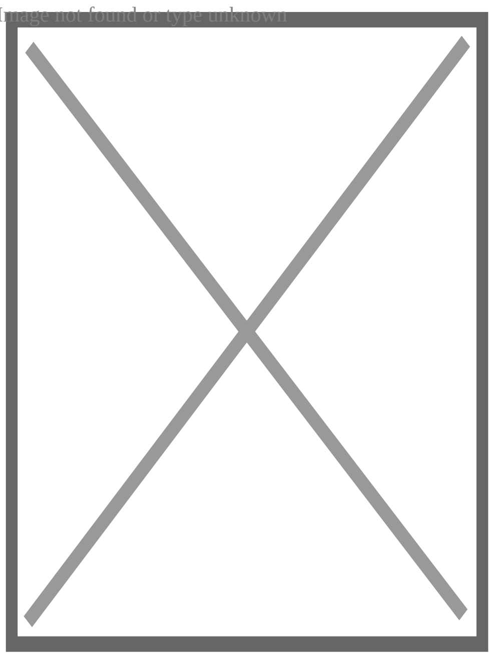


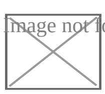
Strandberg Boden Plini **neck-thru** & **bolt on** versions that both utilize carbon fiber reinforcement strips to maintain rigidity.

CFRPs are being used in an increasing number of high-end products that require stiffness and low weight, these include:

- Musical instruments, including violin bows; guitar picks, guitar necks (fitted with carbon fiber rods), **pickguards**/scratchplates; drum shells; bagpipe chanters; piano actions; and entire musical instruments such as carbon fiber cellos, violas, and violins, acoustic guitars and ukuleles; also, audio components such as turntables and loudspeakers.
- Firearms use it to replace certain metal, wood, and fiberglass components but many of the internal parts are still limited to metal alloys as current reinforced plastics are unsuitable.
- High-performance drone bodies and other radio-controlled vehicle and aircraft components such as helicopter rotor blades.
- Lightweight poles such as: tripod legs, tent poles, fishing rods, billiards cues, walking sticks, and high-reach poles such as for window cleaning.
- Dentistry, **carbon fiber posts** are used in restoring root canal treated teeth.
- Railed train **bogies** for passenger service. This reduces the weight by up to 50% compared to metal bogies, which contributes to energy savings.[43]
- Laptop shells and other high performance cases.
- Carbon woven fabrics.[44][45]
- Archery: carbon fiber arrows and bolts, **stock** (for crossbows) and **riser** (for vertical bows), and rail.
- As a filament for the 3D fused deposition modeling printing process,[46] carbon fiber-reinforced plastic (polyamide-carbon filament) is used for the production of sturdy but lightweight tools and parts due to its high strength and tear length.[47]
- District heating pipe rehabilitation, using a **CIPP** method.

Disposal and recycling

[**edit**]



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The key aspect of recycling fiber-reinforced polymers is preserving their mechanical properties while successfully recovering both the **thermoplastic** matrix and the reinforcing fibers. CFRPs have a long service lifetime when protected from the sun. When it is time to decommission CFRPs, they cannot be melted down in air like many metals. When free of vinyl (PVC or **polyvinyl chloride**) and other halogenated polymers, CFRPs recycling processes can be categorized into four main approaches: mechanical, **thermal**, chemical, and biological. Each method offers distinct advantages in terms of material or **energy recovery**, contributing to **sustainability** efforts in composite waste management.

Process	Matrix recovery	Fiber recovery	Degradation of Mechanical Properties	Advantages/Drawbacks
Mechanical	X	X	X	+No use of hazardous chemical substances +No gas emissions +Low-cost energy needed +Big volumes can be recycled -Poor bonding between fiber/matrix -Fibers can damage the equipment
Chemical		X		+Long clean fibers +Retention of mechanical properties +Sometimes there is high recovery of the matrix -Expensive equipment -Possible use of hazardous solvent
Thermal		X	X	+Fiber length retention +No use of hazardous chemical substances +better mechanical properties than mechanical approach +Matrix used to produce energy -Recovered fiber properties highly influenced by process parameters -some processes have no recovery of matrix material

Mechanical Recycling

[**edit**]

The mechanical process primarily involves **grinding**, which breaks down composite materials into pulverulent charges and fibrous reinforcements. This method is focused on both the thermoplastic and filler material recovery; however, this process shortens the fibers dramatically. Just as with **downcycled** paper, the shortened fibers cause the recycled material to be weaker than the original material. There are still many industrial applications that do not need the strength of full-length carbon fiber reinforcement. For example, chopped reclaimed carbon fiber can be used in consumer electronics, such as laptops. It provides excellent reinforcement of the polymers used even if it lacks the strength-to-weight ratio of an aerospace component.**[48]**

Electro fragmentation

[**edit**]

This method consists in shredding CFRP by pulsed **electrical discharges**. Initially developed to extract crystals and precious stones from mining rocks, it is now expected to be developed for composites. The material is placed in a vessel containing water and two **electrodes**. The high voltage electrical pulse generated between the electrodes (50-200 kV) fragments the material into smaller pieces.**[49]** The inconvenient of this technique is that the energy consumed is 2.6 times the one of a mechanical route making it not economically competitive in terms of energy saving and needs further investigation.

Thermal Recycling

[**edit**]

Thermal processes include several techniques such as **incineration**, **thermolysis**, **pyrolysis**, **gasification**, fluidized bed processing, and **cement plant** utilization. This processes imply the recovery of the fibers by the removal of the **resin** by volatilizing it, leading to by-products such as gases, liquids or inorganic matter.**[50]**

Oxidation in fluidized bed

[**edit**]

This technique consists in exposing the composite to a hot and **oxygen-rich** flow, in which it is combusted (450–550 °C, 840–1,020 °F) . The working temperature is selected in function of the matrix to be **decomposed**, to limit damages of the fibers. After a shredding step to 6-20 mm size, the composite is introduced into a bed of **silica sand**, on a metallic mesh, in which the resin will be decomposed into oxidized molecules and fiber filaments. These components will be carried up with the air stream while heavier particles will sink in the bed. This last point is a great advantage for contaminated end-of-life products, with painted surfaces, **foam cores** or metal insert. A **cyclone** enables the recovery of fibers of length ranging between 5 and 10 mm and with very little contamination . The matrix is fully oxidized in a second burner operating at approximatively 1,000 °C (1,850 °F) leading to **energy recovery** and a clean flue gas.[51]

Chemical Recycling

[**edit**]

The chemical recycling of CFRPs involves using a reactive **solvent** at relatively low temperatures (below 350°C) to break down the resin while leaving the fibers intact for reuse. The solvent degrades the composite matrix into smaller molecular fragments (**oligomer**), and depending on the chosen solvent system, various processing parameters such as temperature, pressure, and **catalysts** can be adjusted to optimize the process. The solvent, often combined with **co-solvents** or catalysts, penetrates the composite and **breaks specific chemical bonds**, resulting in recovered **monomers** from the resin and clean, long fibers with preserved mechanical properties. The required temperature and pressure depend on the type of resin, with **epoxy resins** generally needing higher temperatures than polyester resins. Among the different reactive mediums studied, water is the most commonly used due to its environmental benefits. When combined with **alkaline** catalysts, it effectively degrades many resins, while **acidic** catalysts are used for more resistant polymers. Other solvents, such as **ethanol**, **acetone**, and their mixtures, have also been explored for this process.

Despite its advantages, this method has some limitations. It requires specialized equipment capable of handling **corrosive** solvents, hazardous chemicals, and high temperatures or pressures, especially when operating under **supercritical** conditions. While extensively researched at the laboratory scale, industrial adoption remains limited, with the technology currently reaching a **Technology Readiness Level** (TRL) of 4 for carbon fiber recycling.[52]

Dissolution Process

[**edit**]

The dissolution process is a method used to recover both the polymer matrix and fibers from thermoplastic composites without breaking **chemical bonds**. Unlike **solvolysis**, which involves the **chemical degradation** of the polymer, dissolution simply dissolves the polymer chains into a solvent, allowing for material recovery in its original form. An energy analysis of the process indicated that dissolution followed by **evaporation** was more energy-efficient than **precipitation**. Additionally, avoiding precipitation helped minimize polymer loss, improving overall material recovery efficiency. This method offers a promising approach for sustainable recycling of thermoplastic composites.[53]

Biological Recycling

[**edit**]

The biological process, though still under development, focuses on **biodegradation** and **composting**. This method holds promise for bio-based and agro-composites, aiming to create an environmentally friendly end-of-life solution for these materials. As research advances, biological recycling may offer an effective means of reducing plastic composite waste in a sustainable manner.[54]

Carbon nanotube reinforced polymer (CNRP)

[**edit**]

In 2009, **Zyvex Technologies** introduced carbon nanotube-reinforced epoxy and carbon **pre-pregs**.[55] **Carbon nanotube** reinforced polymer (CNRP) is several times stronger and tougher than typical CFRPs and is used in the **Lockheed Martin F-35 Lightning II** as a structural material for aircraft.[56] CNRP still uses carbon fiber as the primary reinforcement,[57] but the binding matrix is a carbon nanotube-filled epoxy.[58]

See also

[**edit**]

- **Carbon fibers** – Material fibers about 5–10 ?m in diameter composed of carbon
- **Composite repair** – Composite repair patch preparation and application
- **Mechanics of Oscar Pistorius's running blades** – Blades used by South African Paralympic runner Oscar Pistorius
- **Reinforced carbon–carbon** – Graphite-based composite material
- **Forged carbon fiber**
- **Carbon-ceramic**
- **Carbotanium**

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About Soil mechanics

Soil auto mechanics is a branch of dirt physics and used auto mechanics that explains the habits of dirts. It varies from fluid auto mechanics and strong mechanics in the feeling that dirts consist of a heterogeneous blend of liquids (typically air and water) and particles (generally clay, silt, sand, and gravel) but soil may also include natural solids and other matter. In addition to rock auto mechanics, dirt auto mechanics provides the academic basis for analysis in geotechnical engineering, a subdiscipline of civil design, and design geology, a subdiscipline of geology. Dirt technicians is utilized to analyze the contortions of and flow of fluids within natural and man-made frameworks that are sustained on or made of soil, or structures that are hidden in soils. Example applications are constructing and bridge structures, keeping walls, dams, and hidden pipeline systems. Principles of soil auto mechanics are likewise used in relevant techniques such as geophysical design, seaside design, farming design, and hydrology. This write-up describes the genesis and make-up of dirt, the difference between pore water pressure and inter-granular efficient tension, capillary activity of fluids in the soil pore rooms, soil classification, infiltration and permeability, time reliant adjustment of volume as a result of pressing water out of tiny pore areas, likewise referred to as combination, shear strength and stiffness of soils. The shear stamina of soils is mainly originated from friction in between the fragments and interlocking, which are very

conscious the reliable tension. The post wraps up with some instances of applications of the concepts of soil technicians such as incline security, side planet stress on maintaining walls, and bearing capability of foundations.
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If the foundation damage *is* covered, what are my deductible and policy limits for structural repairs?

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